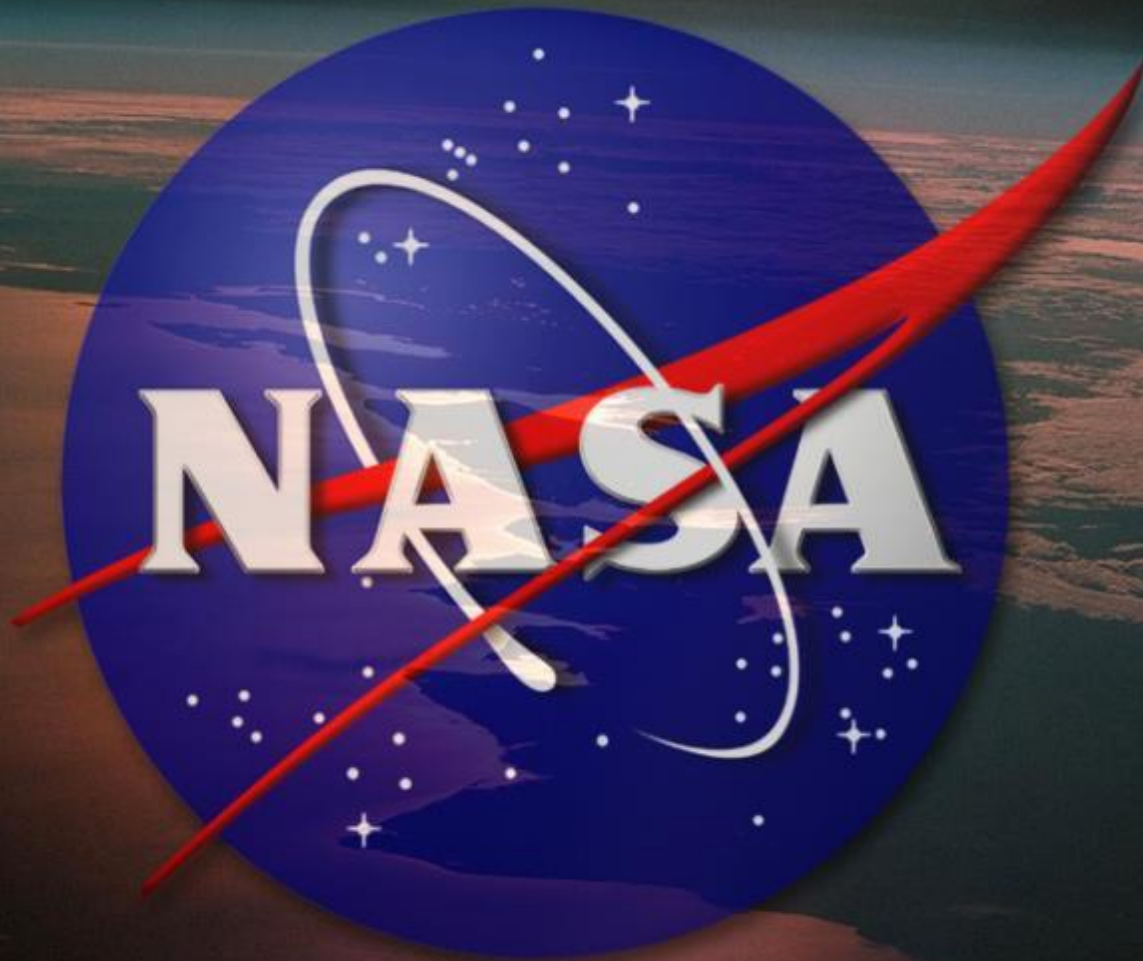


# Welcome to JSC



Liftoff Summer Institute July 2017 Presentation V2



# Where Do We Go From Here?

Tim Hall

NASA Johnson Space Center

June 2017





# First, What's Going On Now At NASA Today?



# Human Spaceflight....



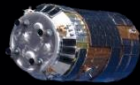
Expedition 52



Expedition 53



JAXA HTV



SpaceX  
Dragon

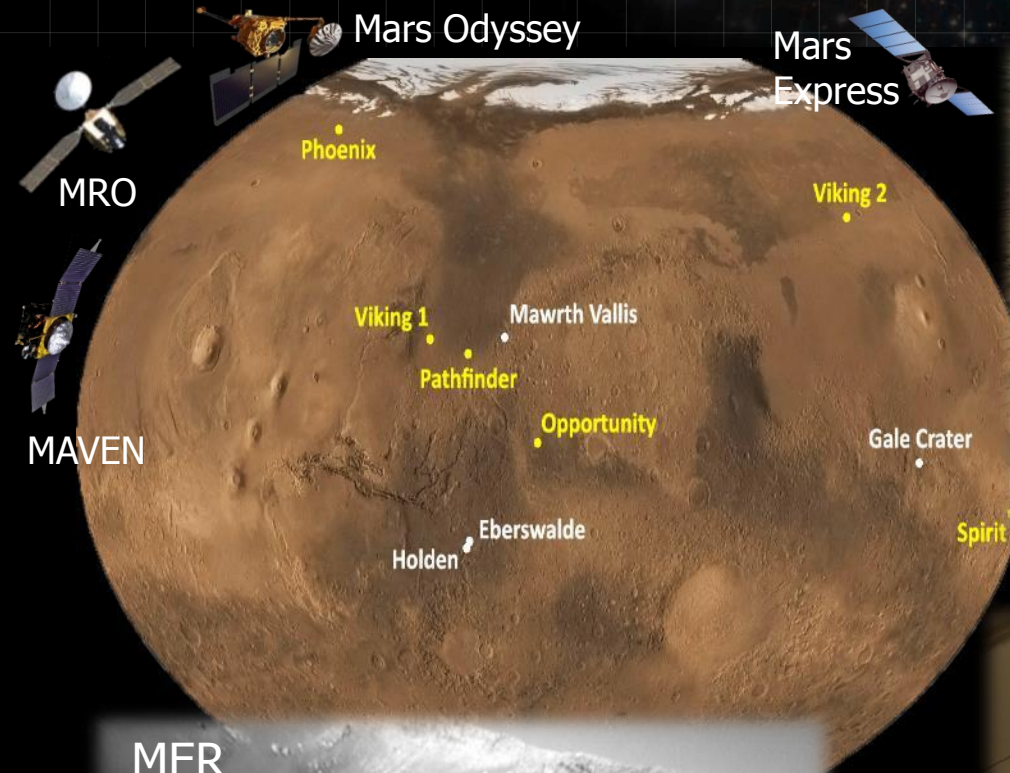


Orbital Sciences  
ATK Cygnus





# Planetary Missions, Mars is busy!...



MSL- Mars Science Laboratory  
"Curiosity"



MSL Selfie

MER  
Mars Exploration  
Rover—  
"Opportunity"



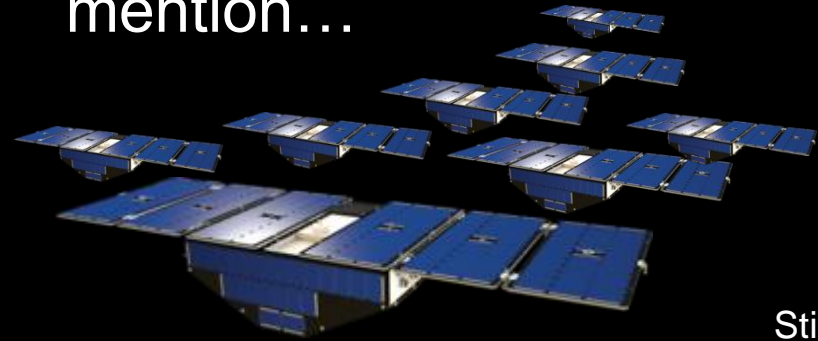
MSL Wear and Tear

<http://www.space.com/16874-where-did-nasa-spacecraft-land-on-mars-video.html>

# Many, many other cool missions...

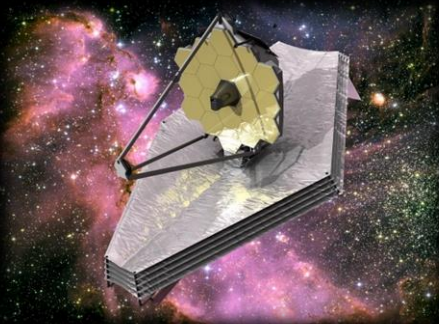


Just a few to mention...



## Cyclone Global Navigation Satellite System (CYGNSS)

is a space-based multi satellite system developed to improve hurricane forecasting

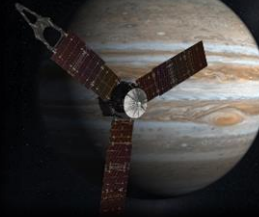


## James Webb Telescope

Launch in 2019

## Juno

Arrived at Jupiter July 2016



## Hubble

Still researching origins of the universe

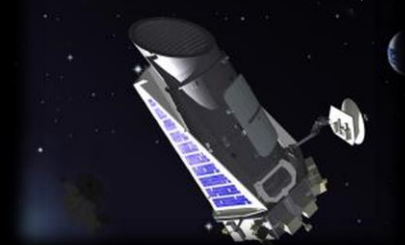


## Kepler

Planet Count

Confirmed Planets: 977

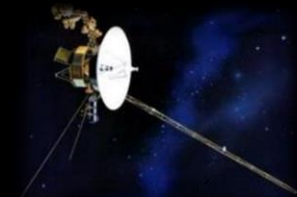
Planet Candidates: 4,234



## Voyager 1

Has left the building...

Traveling interstellar space



## Eyes on the Solar System

<http://eyes.nasa.gov/>



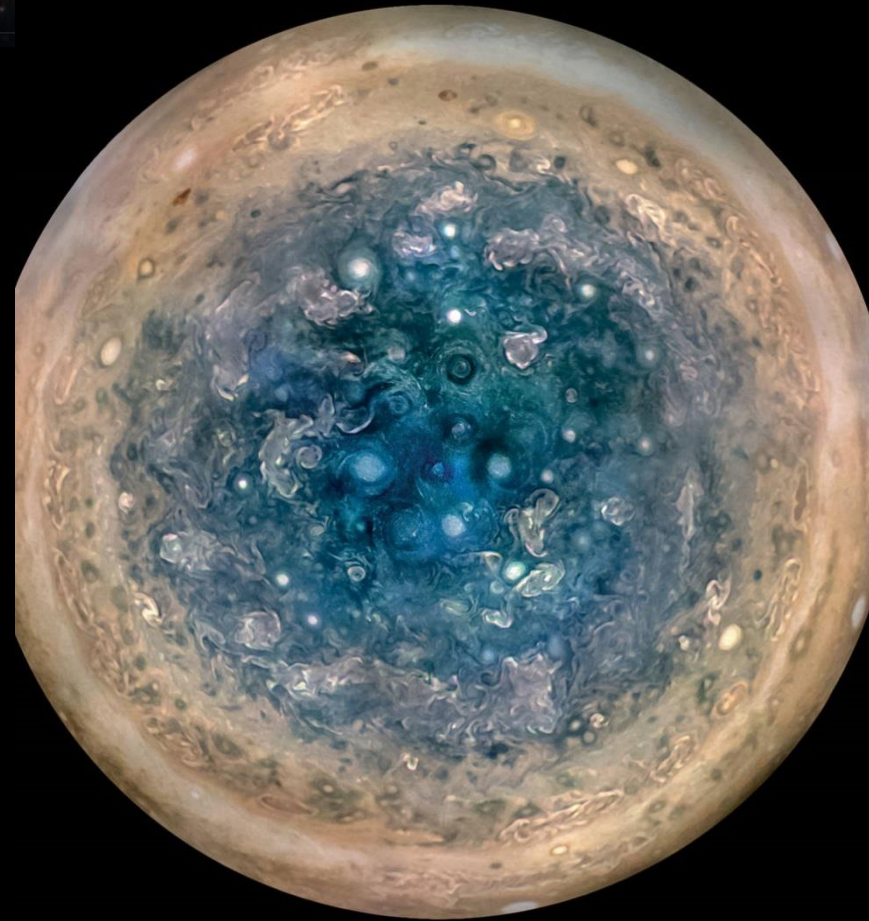
# Jupiter – JUNO



- Juno is a NASA space probe orbiting the planet Jupiter.
  - It is operated by NASA's Jet Propulsion Laboratory. The spacecraft was launched from Cape Canaveral Air Force Station on August 5, 2011,
  - Juno entered a polar orbit of Jupiter on July 5, 2016 to begin a scientific investigation of the planet.
  - After completing its mission, Juno will be intentionally deorbited into Jupiter's atmosphere.[8]
- Juno's mission is to measure Jupiter's composition, gravity field, magnetic field, and polar magnetosphere.
  - It will also search for clues about how the planet formed, including whether it has a rocky core, the amount of water present within the deep atmosphere, mass distribution, and its deep winds, which can reach speeds of 618 kilometers per hour (384 mph)

"It's snowing on Jupiter, and we're seeing how it works," Juno principal investigator Scott Bolton, of the Southwest Research Institute in San Antonio

Zoomed-in view of a photo taken by NASA's Juno probe on May 19, 2017, showing clouds of water ice and/or ammonia ice high up in Jupiter's atmosphere in the south tropical zone.



# Jupiter – Juno



- This enhanced-color image of Jupiter's bands of light and dark clouds was created by citizen scientists Gerald Eichstädt and Seán Doran using data from the JunoCam imager on NASA's Juno spacecraft.
- Three of the white oval storms known as the "String of Pearls" are visible near the top of the image. Each of the alternating light and dark atmospheric bands in this image is wider than Earth, and each rages around Jupiter at hundreds of miles (kilometers) per hour. The lighter areas are regions where gas is rising, and the darker bands are regions where gas is sinking.
- Juno acquired the image on May 19, 2017, at 11:30 a.m. PST (2:30 p.m. EST) from an altitude of about 20,800 miles (33,400 kilometers) above Jupiter's cloud tops.



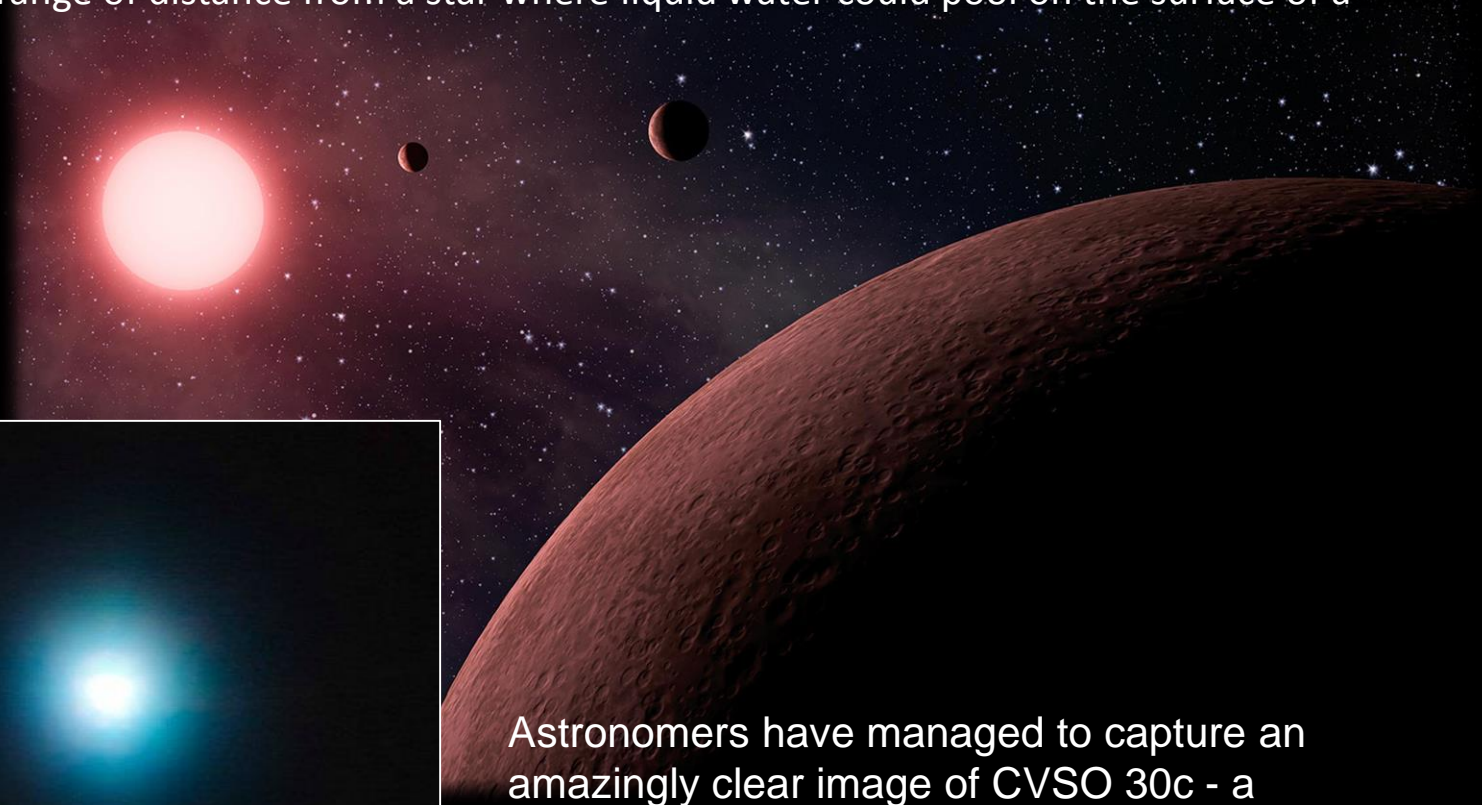


# Exoplanets



## NASA Finds 219 Possible Planets, Including 10 'Earths'

NASA's Kepler space telescope team has released a mission catalog of planet candidates that introduces 219 new candidates, 10 of which are near-Earth size and orbiting in their star's habitable zone, which is the range of distance from a star where liquid water could pool on the surface of a rocky planet.?



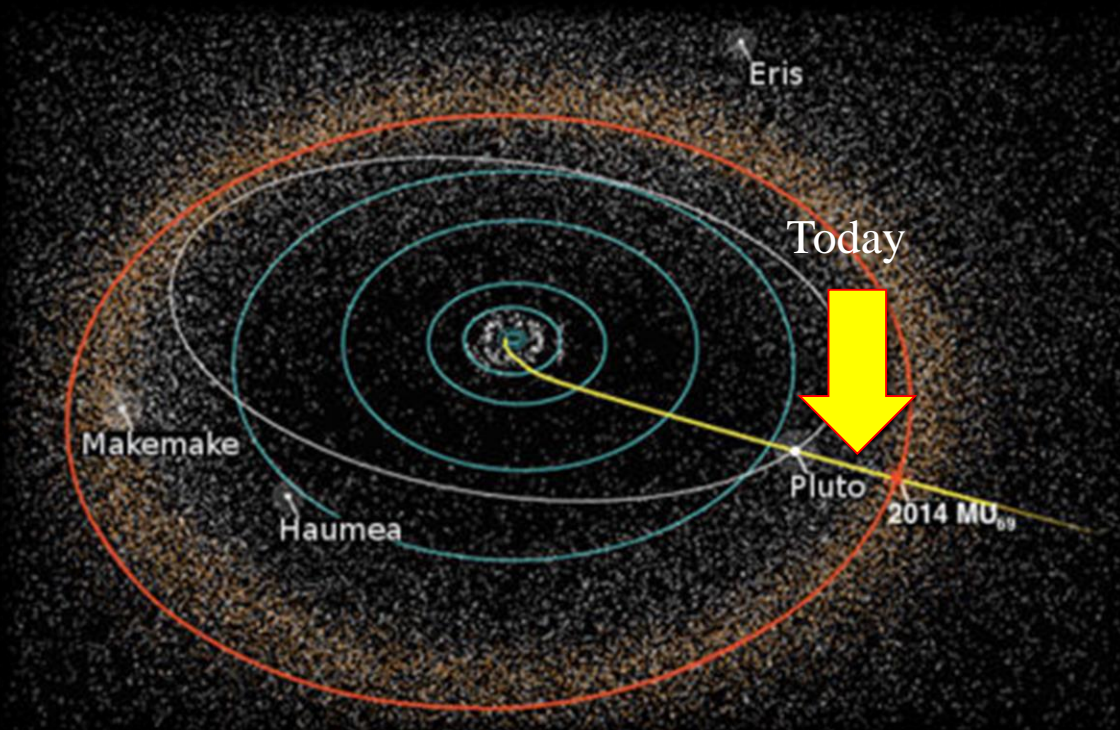
Astronomers have managed to capture an amazingly clear image of CVSO 30c - a potential [exoplanet](#) orbiting a distant star named CVSO 30, that lies some 1,200 light-years away.



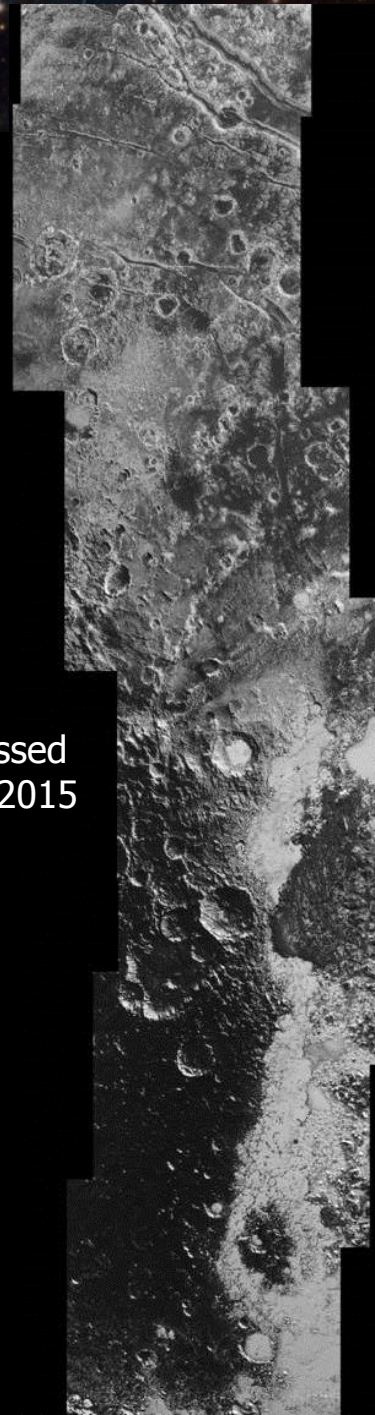
Real Picture

# New Horizons @ Pluto!

- New from NASA's New Horizons:
  - The Spacecraft just passed half way to its next target MU69 in January of 2019



NASA's New Horizons spacecraft passed Pluto in July 2015







# Human Space Flight Vehicles and Plans for Exploration

# Human Space Flight “Vehicles” for ISS

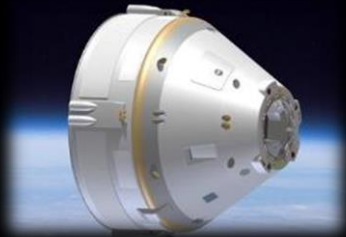


Russian Soyuz



US Space Shuttle

Future US  
Commercial Crew  
Capsules



Boeing CST-100  
Starliner



SpaceX Dragon  
Capsule

- NOTE: ISS Also has Cargo Vehicles for ISS (no human rating)

## Commercial Resupply Vehicles

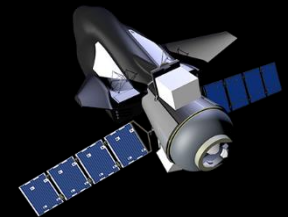
SpaceX  
Dragon  
Cargo



Orbital Sciences  
ATK Cygnus



Sierra Nevada  
Dream Chaser  
Cargo  
(2019)



## International Partner Vehicles

JAXA Space  
Agency  
HTV



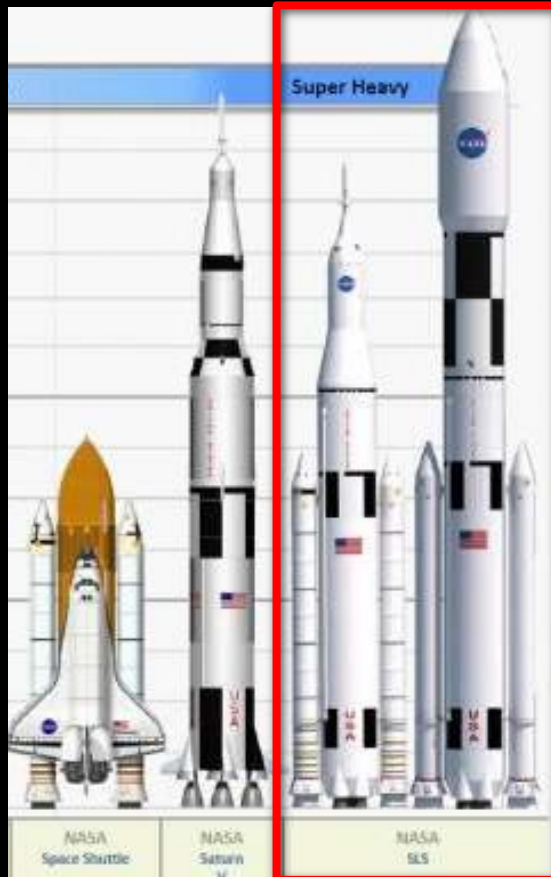


# Human Space Flight “Vehicles” for Exploration



- Exploration

Orion & Service Module



Possible Deep Space Gateway  
(Habitat and Propulsion  
Module and Airlock)

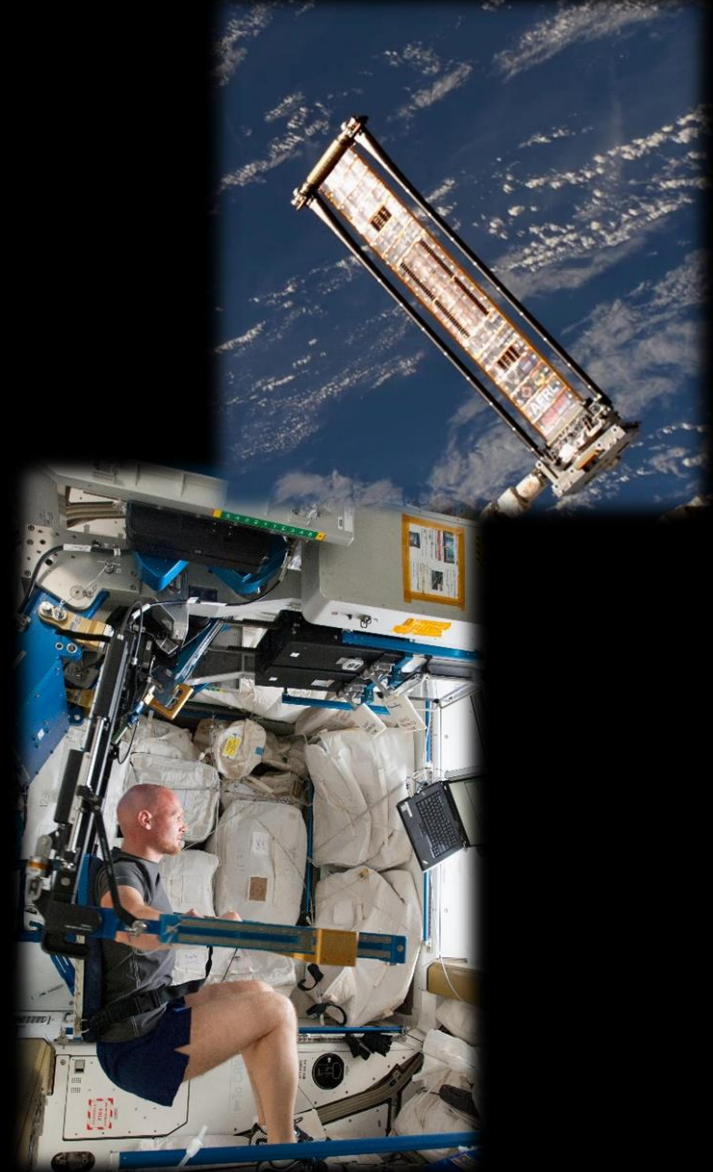


SLS – Space Launch System  
Heavy Lift Vehicle

# NASA Plans to use ISS as Test Bed for Exploration



- Utilize ISS to test out exploration technologies
- These include:
  - Closed Loop Environmental Systems
  - Power Systems
  - Materials for use in deep space environments
  - Human long duration mission mitigations
  - Exploration Space Suit technologies



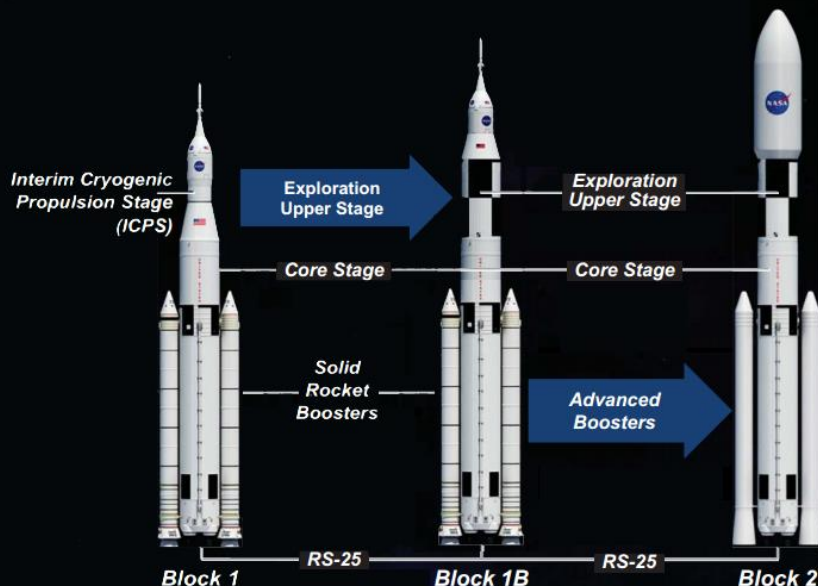
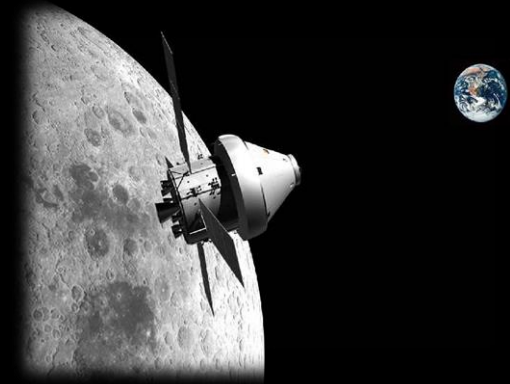


# Orion & SLS Plans



## Orion Program mission schedule

Mission	Acronym	Launch date
Exploration Flight Test 1	EFT-1	December 5, 2014
Exploration Mission 1	EM-1	November 2019
Pad Abort 2	PA-2	December 2018
Exploration Mission 2	EM-2	August 2021





# NASAs Exploration Strategy

As of March 2017



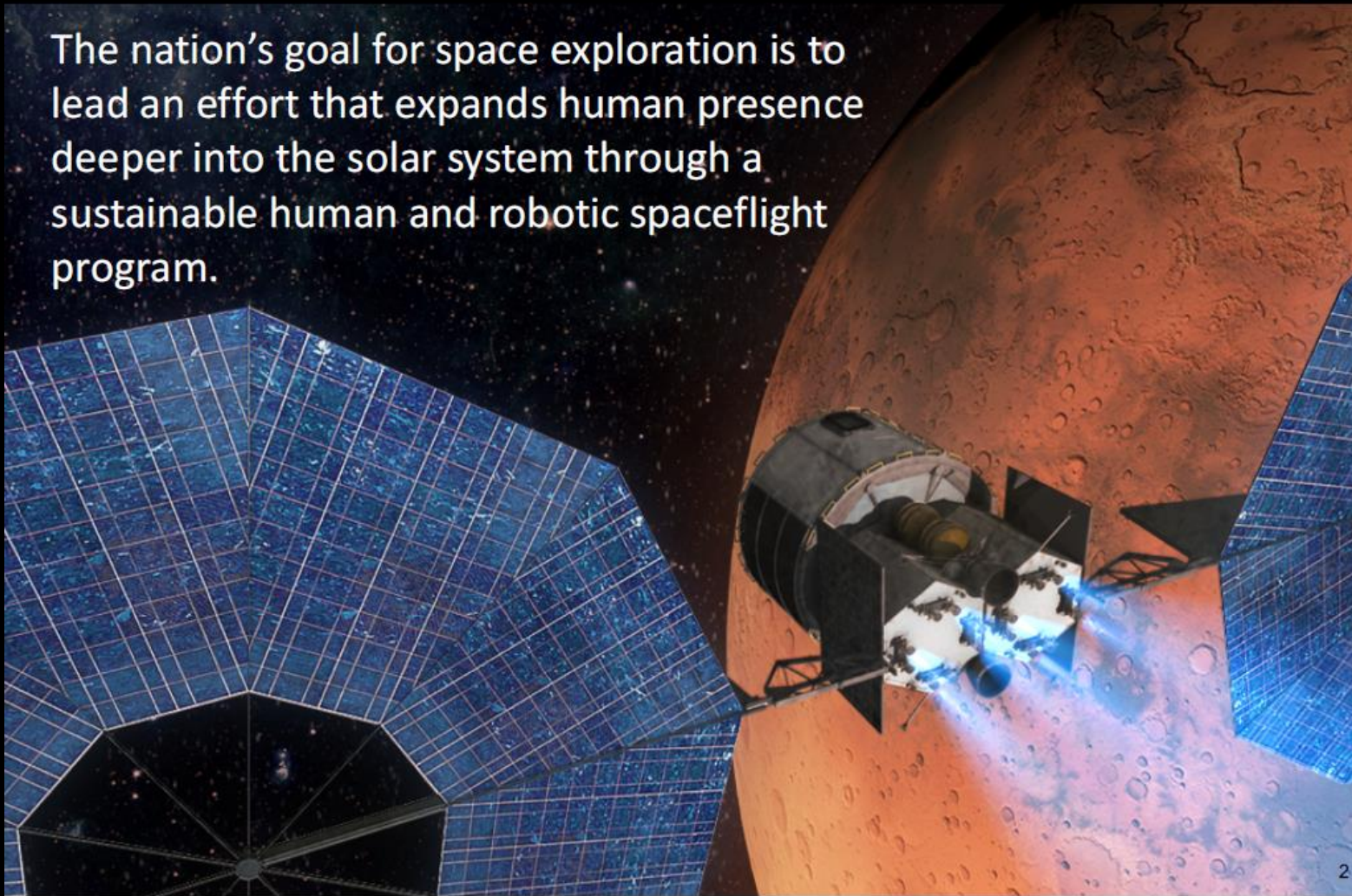
# Exploration



## Our Goal



The nation's goal for space exploration is to lead an effort that expands human presence deeper into the solar system through a sustainable human and robotic spaceflight program.

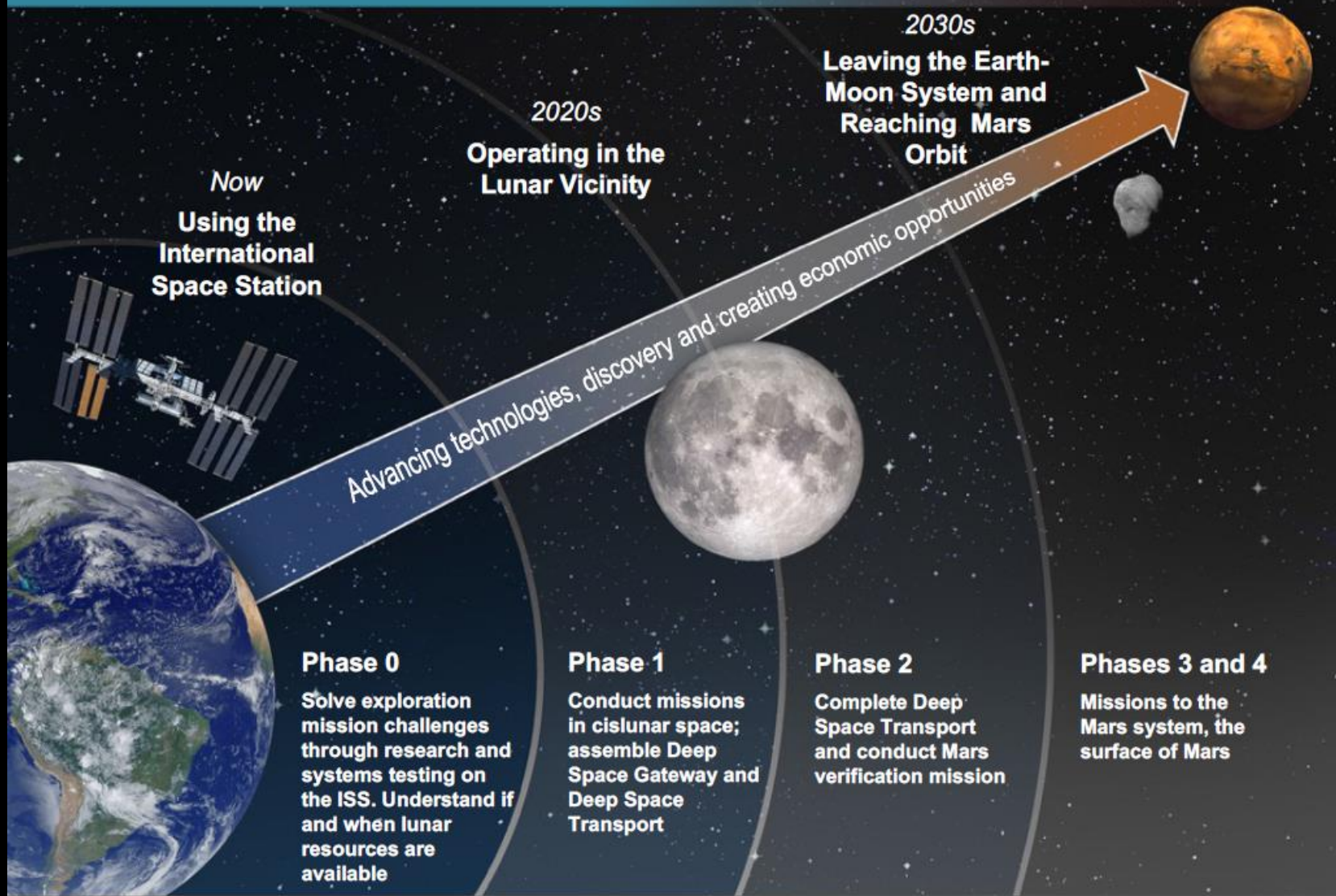




# Exploration Plans



## Exploring Space In Partnership

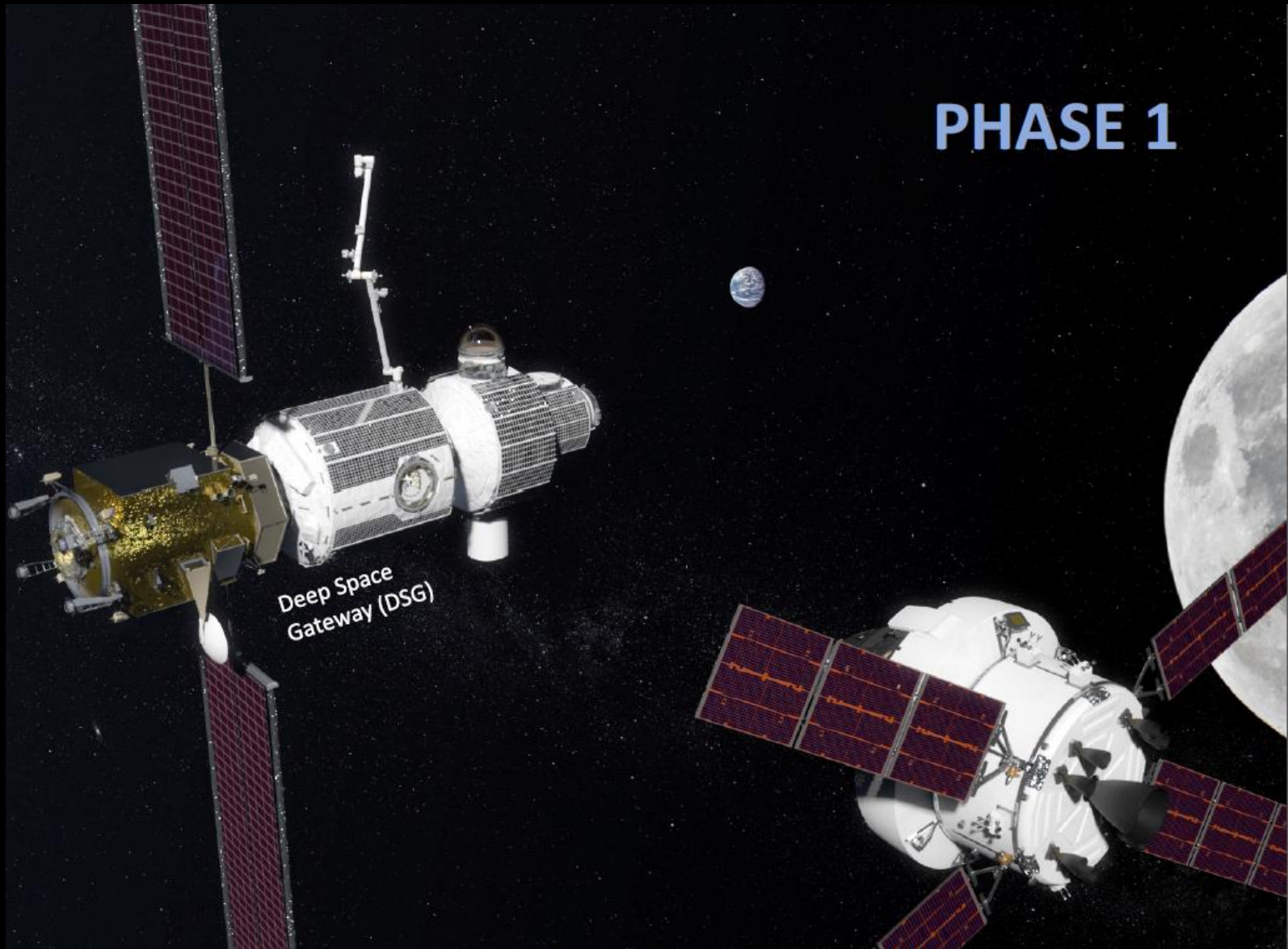




# Deep Space Gateway Functionality



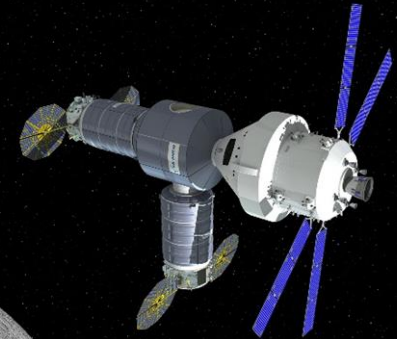
**PHASE 1**



# Deep Space Gateway Cise Lunar Missions



- Lunar orbiting outpost
  - Possible use of L2 (Lagrange point)
  - Science collection from deep space
  - Exploration System Technology Demonstration
- Lunar Base????
  - Science collection
  - Exploration Systems Technology Demonstration
  - Surface Habitat, Lander and Walking suit test bed for Mars





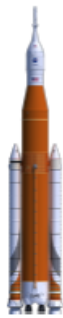
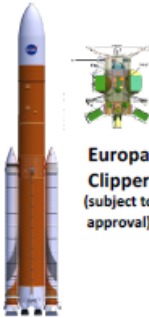
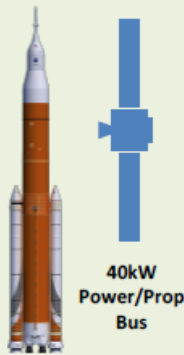

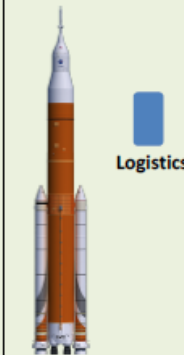
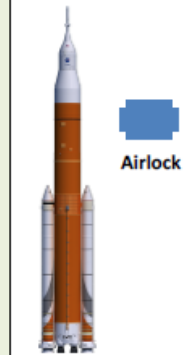







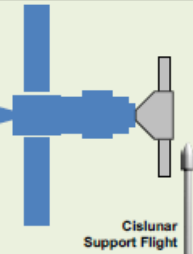
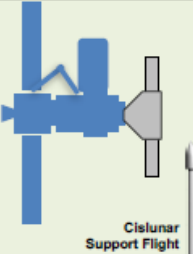
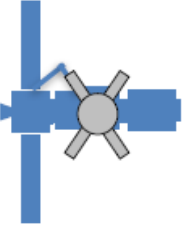
# SLS Capability and Potential Manifest



## Phase 1 Plan

Establishing deep-space leadership and preparing for Deep Space Transport development



Deep Space Gateway Buildup					
EM-1	Europa Clipper	EM-2	EM-3	EM-4	EM-5
2018 - 2025					2026
<b>SLS Block 1</b> Crew: 0  	<b>SLS Block 1B Cargo</b>   Europa Clipper (subject to approval)	<b>SLS Block 1B</b> Crew: 4 CMP Capability: 8-9T   40kW Power/Prop Bus	<b>SLS Block 1B</b> Crew: 4 CMP Capability: 10mT   Habitation	<b>SLS Block 1B</b> Crew: 4 CMP Capability: 10mT   Logistics	<b>SLS Block 1B</b> Crew: 4 CPL Capability: 10mT   Airlock
<b>Distant Retrograde Orbit (DRO)</b> 26-40 days  	<b>Jupiter Direct</b>  	<b>Multi-TLI Lunar Free Return</b> 8-21 days  	<b>Near Rectilinear Halo Orbit (NRHO)</b> 16-26 days  	<b>NRHO, w/ ability to translate to/from other cislunar orbits</b> 26-42 days  	<b>NRHO, w/ ability to translate to/from other cislunar orbits</b> 26-42 days  
<b>Gateway (blue)</b> <b>Configuration</b> <b>(Orion in grey)</b>			 Cislunar Support Flight	 Cislunar Support Flight	

These essential Gateway elements can support multiple U.S. and international partner objectives in Phase 1 and beyond

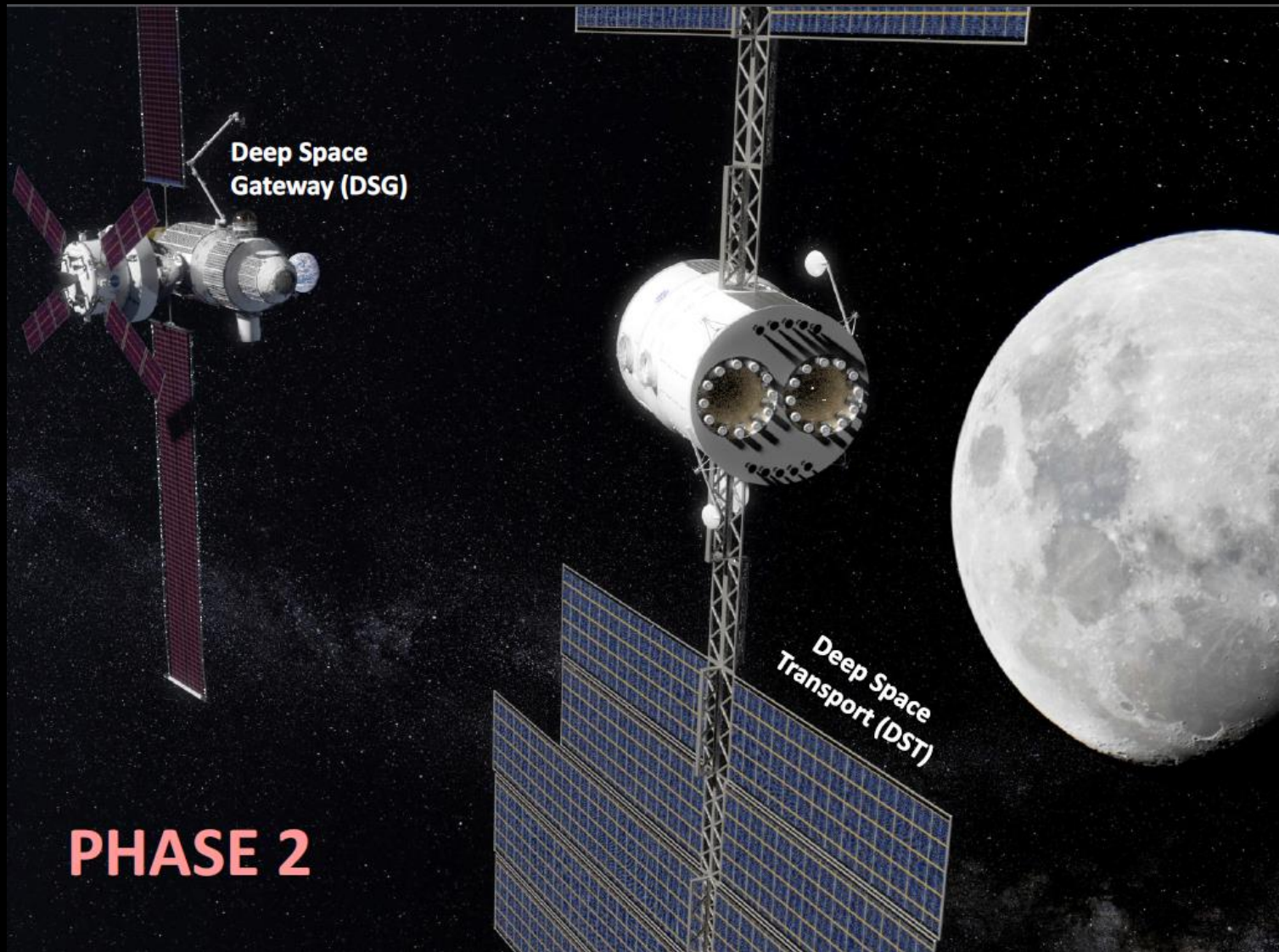
### Known Parameters:

- Gateway to architecture supports Phase 2 and beyond activities
- International and U.S. commercial development of elements and systems
- Gateway will translate uncrewed between cislunar orbits
- Ability to support science objectives in cislunar space

### Open Opportunities:

- Order of logistics flights and logistics providers
- Use of logistics modules for available volume
- Ability to support lunar surface missions

# Exploration Next Phase

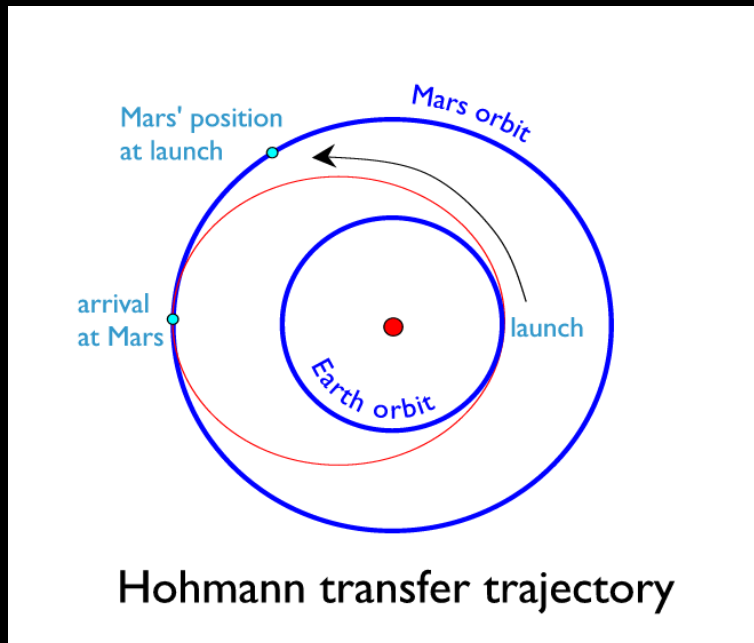




# Human Mars Mission



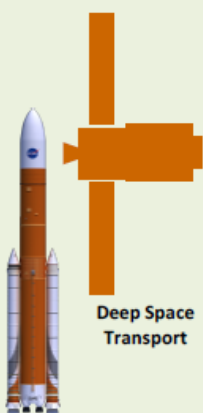
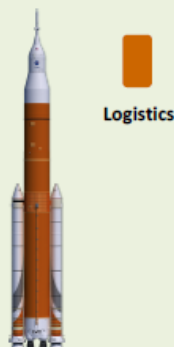

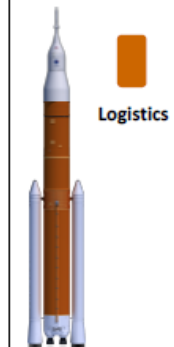

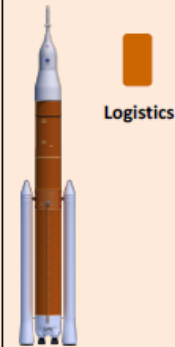
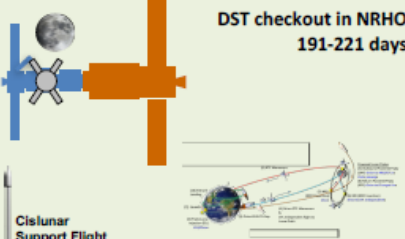


- Extend Mission Durations
- Test out Deep Space Propulsion and cargo systems
- Continue to shrink technology gap for exploration outside Earth/Moon region
- Last Phase would be a Mars transit from Deep Space Gateway



Images Credit: The Martian/20<sup>th</sup> Century Fox

## (PLANNING REFERENCE) Phase 2 and Phase 3

Looking ahead to the shakedown cruise and the first crewed missions to Mars

Transport Delivery		Transport Shakedown		Mars Transit	
EM-6	EM-7	EM-8	EM-9	EM-10	EM-11
2027		2028 / 2029		2030+	
<p>SLS Block 1B Cargo P/L Capability: 41t TLI</p>  <p>Deep Space Transport</p>	<p>SLS Block 1B Crew: 4 CMP Capability: 10t</p>  <p>Logistics</p>	<p>SLS Block 1B Cargo P/L Capability: 41t TLI</p>  <p>DST Logistics &amp; Refueling</p>	<p>SLS Block 2 Crew: 4 CMP Capability: 13+t</p>  <p>Logistics</p>	<p>SLS Block 2 Cargo P/L Capability: 45t TLI</p>  <p>DST Logistics &amp; Refueling</p>	<p>SLS Block 2 Crew: 4 CMP Capability: 13+t</p>  <p>Logistics</p>
 <p>DST checkout in NRHO 191-221 days</p> <p>Cislunar Support Flight</p>		 <p>DSG: continued operations in cislunar space</p> <p>DST: shakedown in cislunar space with return to DSG in NRHO 300-400 days</p> <p>Cislunar Support Flight</p>		 <p>DSG: continued operations in cislunar space</p> <p>DST: Mars transit and return to DSG in NRHO</p> <p>Cislunar Support Flight</p>	

Reusable Deep Space Transport supports repeated crewed missions to the Mars vicinity

### Known Parameters:

- DST launch on one SLS cargo flight
- DST shakedown cruise by 2029
- DST supported by a mix of logistics flights for both shakedown and transit
- Ability to support science objectives in cislunar space

### Open Opportunities:

- Order of logistics flights and logistics providers
- Shakedown cruise vehicle configuration and destination/s
- Ability to support lunar surface missions





# So what does it take to explore Deep Space?

# Space Exploration Challenges...



- Who would you need on a deep space mission?

## Standard for LEO today

- Pilot
- Scientist
- Engineer

## Required Systems Experts for Exploration Missions

- Propulsion
- Navigation
- Communication
- Environmental (Plumber, AC, Heat)
- Power
- Stowage/Inventory

- Other crew, required?

- Doctor
- Dentist
- Psychologist
- Geologist
- IT/Computer
- Machinist
- Handyman
- Sheriff
- Judge/Lawyer

**20+  
People???**





# Space Exploration Challenges...



- Up mass
  - Exploration Vehicle – est. 100 tons of material and supplies (ISS 420 tons)
- Propulsion
  - Chemical, Ion, Solar Electric
- Environmental Systems
  - Closed loop, Reliability, Redundancy
- Automation
  - Self maintaining systems
- Radiation Shielding
  - Crew and systems health
- Communication
  - Comm delays increase
- Long Range Human Health Affects
  - Bone health, eye damage, long term radiation exposure
- Stowage/Logistics



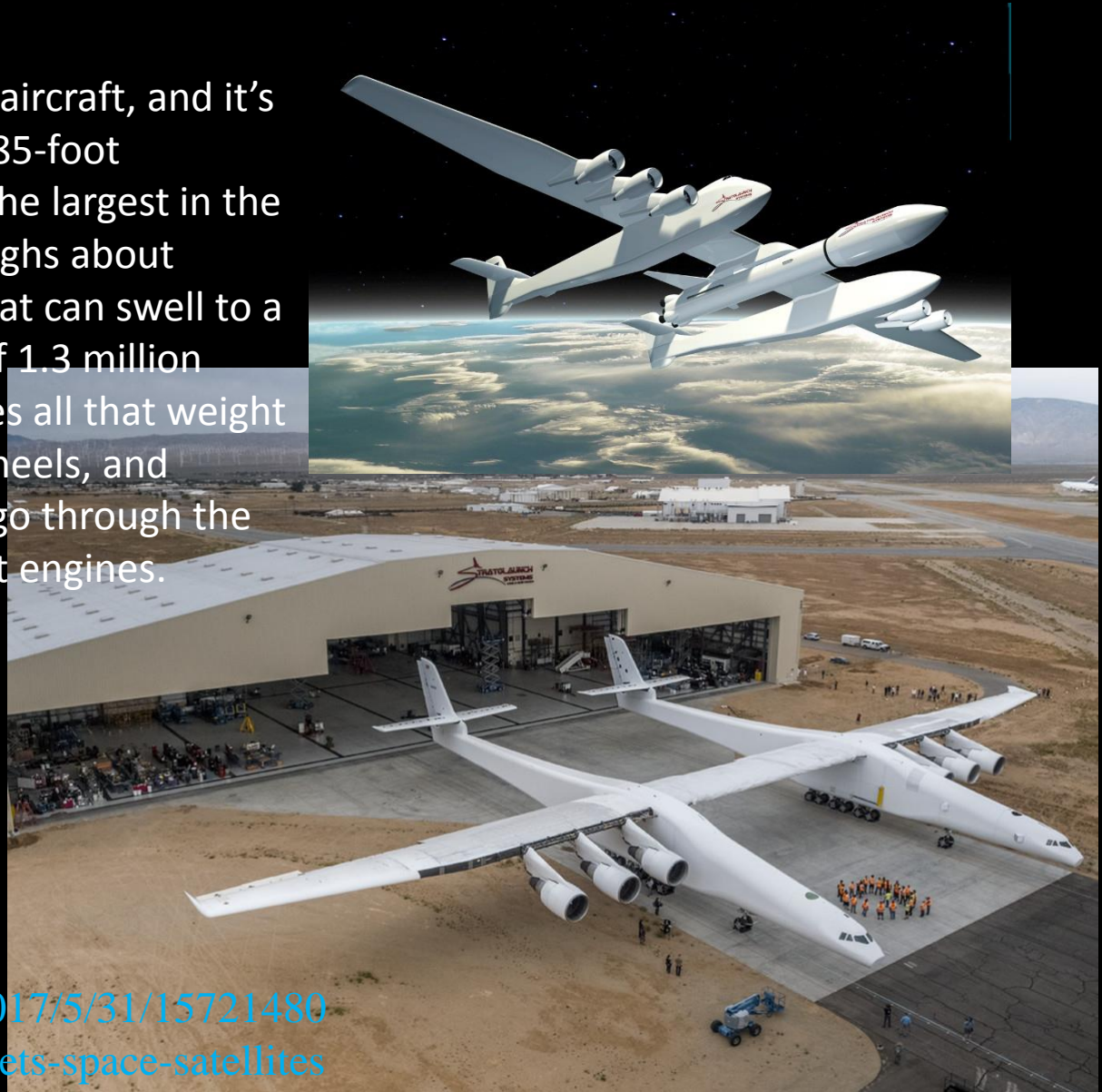
# Other Current Topics of Interest for Students



# Stratolaunch - Microsoft co-founder built the world's largest plane to launch rockets into space



It's called the Stratolaunch aircraft, and it's massive. The plane has a 385-foot wingspan, which makes it the largest in the world by that metric. It weighs about 500,000 pounds dry, but that can swell to a maximum takeoff weight of 1.3 million pounds. Stratolaunch moves all that weight across the ground on 28 wheels, and eventually will carry its cargo through the air thanks to six 747 aircraft engines.



<https://www.theverge.com/2017/5/31/15721480/stratolaunch-paul-allen-rockets-space-satellites>

# First Private Moon Landing Gears Up for Launch by Year's End



Moon Express and Rocket Lab are poised to make history.

Moon Express (or MoonEx), a space exploration company powered by industry engineers and Silicon Valley money, is making the final adjustments to its lunar lander in its facilities at Cape Canaveral. Its goal is to achieve something that has only been accomplished by the three largest superpowers in the world: a soft landing on the moon.

"It will be the space equivalent of the four-minute mile. I think we're going to redefine the possible," MoonEx co-founder and CEO Bob Richards tells *Popular Mechanics*. "We've seen this throughout history—everybody thinks something is impossible until they see it done."



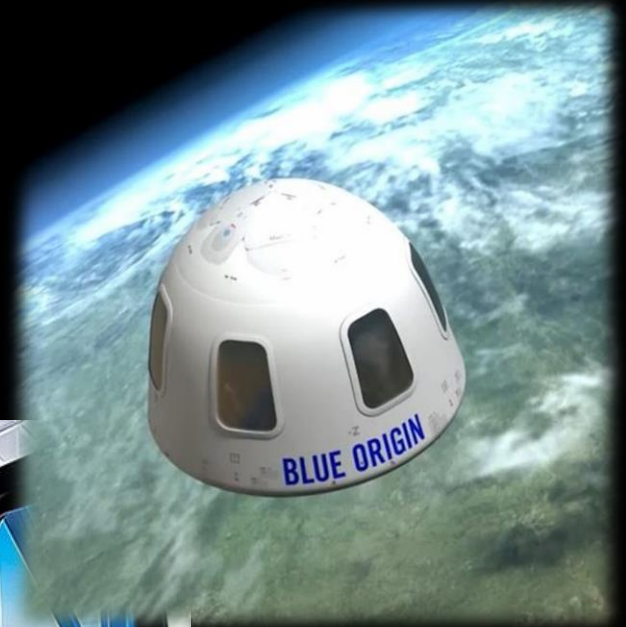
<http://www.popularmechanics.com/space/moon-mars/a26702/moon-express-lunar-landing-launch-years-end/>



# Blue Origin Rides into Space

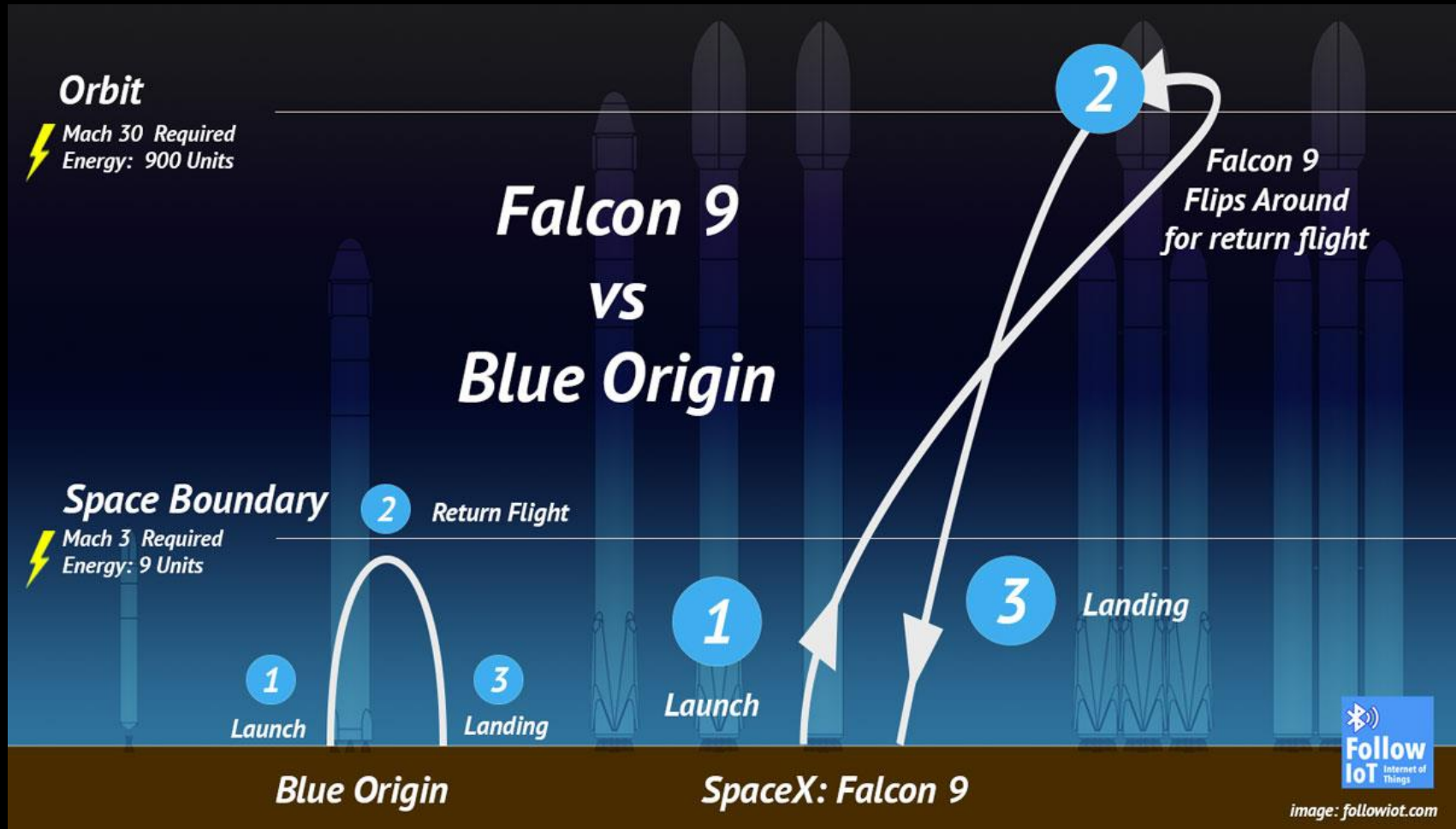


Blue Origin released new images today (March 29) of the interior of its New Shepard passenger capsule, which the company says will be used to send paying customers on brief trips into space.



<https://www.space.com/36267-blue-origin-space-capsule-interior-sneak-peek.html>

# Interesting Look at Blue Origin vs SpaceX







**Questions?**

**Thank You!**



# My favorites...



# My favorite sites and links...



- Heavens Above
  - <http://heavens-above.com/>
- NASA Spinoffs
  - <http://spinoff.nasa.gov/>
- Eyes on the Solar System
  - <http://eyes.nasa.gov/>
  - Youtube NASA Television
    - <http://www.youtube.com/user/NASAtlevision>
    - Youtube Earth Video
      - <http://www.youtube.com/watch?v=lp2ZGND1I9Q>
      - ISS Tour by CDR/Suni Williams
        - <http://www.youtube.com/watch?v=doN4t5NkW-k>
        - Why Mars is Hard Stan Love
          - <http://www.youtube.com/watch?v=fturU0u5KJo>
  - Perspectives
    - <http://htwins.net/scale2/?bordercolor=white>
  - ISSLive
    - <http://spacestationlive.jsc.nasa.gov/>
  - Distance Learning Network
    - NASA DLN Website: <http://www.nasa.gov/offices/education/programs/national/dln/index.html>
    - Toolkit with Material and Templates:  
<http://communications.nasa.gov/OCP/Communications%20Tool%20Kit/Presentation%20Template%20Web%20Site/CTK.html>



# JPL – Eyes on the Solar System



Eyes on the Solar System

<http://eyes.nasa.gov/>



<http://htwins.net/scale2/?bordercolor=white>

## Giant Earthworm



Copyright © 2012 Cary and Michael Huang (<http://htwins.net>)

Other languages

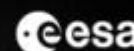
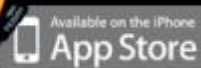
Back

# ISSLive



ISSLive

<http://isslive.com/>





# Youtube – REELNASA



## ReelNASA

[http://www.youtube.com/results?search\\_query=reelnasa&sa=X&spell=1&search=Search&oi=spell](http://www.youtube.com/results?search_query=reelnasa&sa=X&spell=1&search=Search&oi=spell)

A screenshot of a YouTube search results page for the query "reelnasa". The page shows the YouTube logo, a search bar with "reelnasa" entered, and a "Filter" dropdown menu. Below the search bar, it says "About 990 results". The search results are listed in a vertical column, each with a video thumbnail, title, description, and view count. The first result is "Reel NASA" by ReelNASA, with 928 videos and 31,508 subscribers. The second result is "Science off the Sphere: Knitting Needle Experiment" by ReelNASA, with 546,686 views. The third result is "We Are the Explorers" by ReelNASA, with 176,084 views. The fourth result is "Chase Plane Video Of Historic SpaceX Splashdown" by ReelNASA, with 70,754 views. The fifth result is "Science off the Sphere: Gool" by ReelNASA, with 8,412 views. The sixth result is "Interview with NASA Earth Scientist Melissa Davares" by ReelNASA, with 1,111 views.

**You Tube** reelnasa Browse | Mov

Filter ▾ About 990 results

**Reel NASA**  
Get off my planet. Give me my space. Get real with **Reel NASA**. Space trav ...  
ISS Update: Dr. Steve Squyres, NEEMO 16 Aquanaut and Cornell Professor  
CHANNEL by ReelNASA | 928 videos | 31,508 subscribers

**Science off the Sphere: Knitting Needle Experiment**  
challenge and view future experiments here: www.physicscentral.com ... **Reel NASA** ...  
"Science off the Sphere" "American Physical Society" "Don Pettit" ...  
CC by ReelNASA | 4 months ago | 546,686 views

**We Are the Explorers**  
is helping us lay the foundation for our greatest journeys ahead. ... **Reel NASA** ... NASA  
exploration "Peter Cullen" space flew shuttle station Orion ...  
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**Chase Plane Video Of Historic SpaceX Splashdown**  
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## Office of the Chief Technologist

Value for NASA, Benefits for the Nation

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(brightest) 3.5 | 4.0 | 4.5 (dimmiest)  
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Current position of ISS

+1 523

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